Pb-Free Perovskite Solar Cells Fabrication

Mechanical Engineering

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FRESNO STATE

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Abstract

This research direction investigates into the causes of degradation of efficiency over time in open environments. The best course of action based on the research is to validate the findings of a paper using newly developed alternative techniques. This validation of the findings of the other paper would support the newly developed techniques of fabricating perovskite solar cells. This fabrication is a solution based fabrication in a traditional wet laboratory environment. The testing procedure involves a controlled light source and controlled area of exposure to be able to calculate efficiency. A scanning electron microscope and an EDS is to be used to examine microstructural and elemental properties. Furthermore, an atomic-force microscopy and energy-dispersive X-ray spectroscopy test for surface properties.

Introduction

This research deals with the fabrication, processing, and characterization of perovskite solar cells specifically in the niche area of lead-free perovskite solar cells.[3] In comparison to Si and CdTe based PV research with eight and four decades respectively, perovskite PV cell research is relatively new, under a decade old. Perovskite solar cells in general show great promise as shown in figure 1, even compared to silicon based solar cells. The great thing about perovskite solar cells is that they can be manufactured cheaply in a traditional wet lab environment. Due to the low cost of production and the high efficiency, research in this field is very promising and in high demand. Most research in terms of efficiency has been in lead based perovskite structures. The current research is based on perovskite structures with bismuth (III)-iodide as the base, instead of the traditional lead based perovskite solar cells.

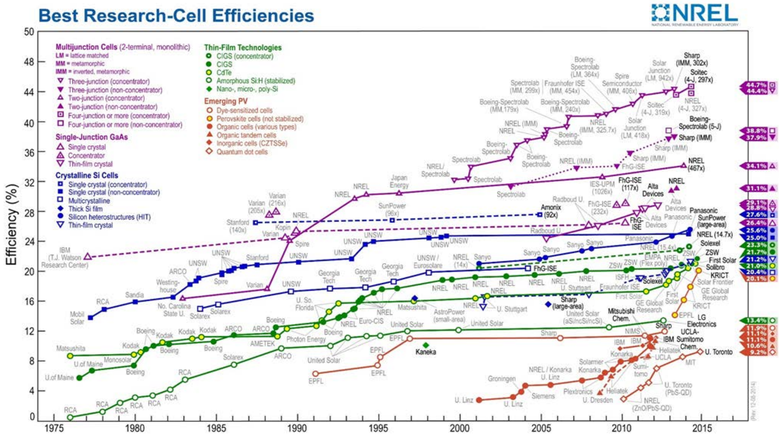


Figure 1: Solar Cell Efficiencies[2]

Perovskite Properties

Perovskite material refers to a specific molecular structure, a cube-octahedral. Table 1 shows the characteristics of the perovskite structure ABX_3.[4] In figure 2 the molecular structure is depicted in a three-dimensional drawing. The advantages of using perovskite for the active/photosensitive layer include but are not limited to broad light absorption spectrum, tunable band gaps, long charge carrier diffusion, and low cost of preparation technology.[6]

Table 1: Perovskite Chemical Formula

Variable	Chemical Type	Examples
A	Organic cation	Methylammonium, Formamidinium
B	Divalent metal ion	Lead, Tin, Bismuth (III)
X	Halide ion	Iodine, Bromine, Chlorine

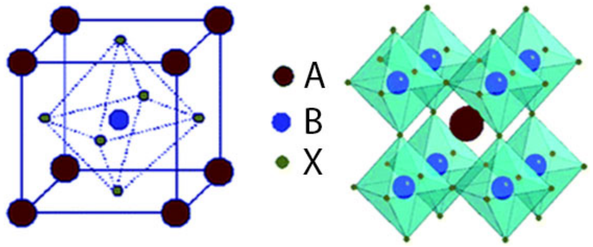
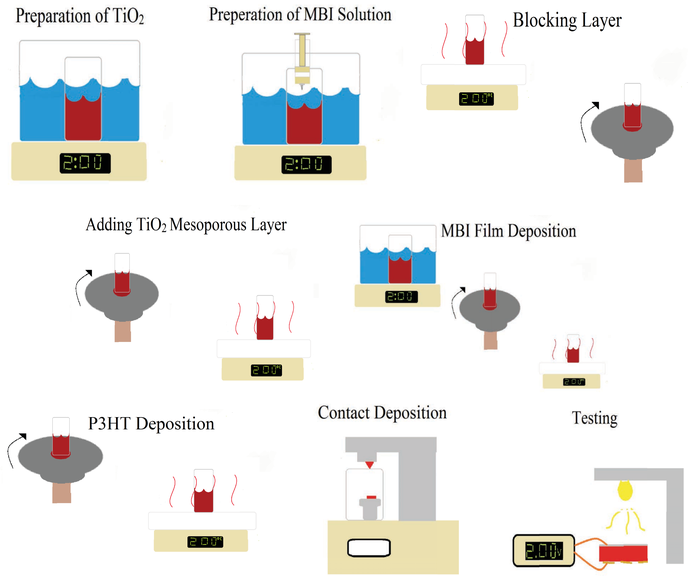


Figure 2: Perovskite Structure[1]

Brief Description of the Fabrication Procedure



Perovskite Layered Structures

There are many different perovskite structures that are used in fabricating solar cells. In figure 4, four different layer structures are depicted. In all versions, perovskite is the active layer which holes and electrons are transported from as shown in figure 3. This is due to energy band gaps. In figure 4a and 4b scaffolding with a mesoporous layer is introduced to improve properties such as stability.[9]

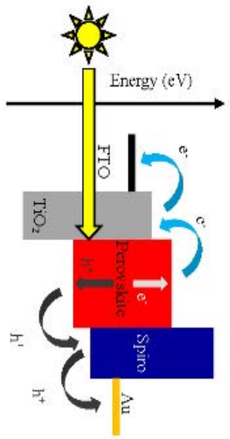


Figure 3: Electron and Hole Transfer[5]

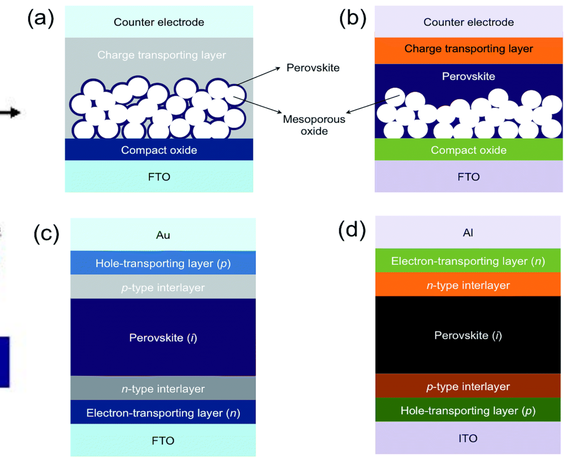


Figure 4: Perovskite Layer Structure[8]

Conclusion

Pb-free perovskite solar cells are being researched in the Lyles College of Engineering at Fresno State. Currently the layered structure with scaffolding along with an overlay of perovskite, shown in figure 4a, is being researched using bismuth (III), due to the promising degradation resistance from the environmental factors.[7] The effectiveness of each trail are being measured by average efficiency with standard deviation. The goal is to promote/further perovskite research as a low cost and environmentally benign solution.

References

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